(12) UK Patent Application (19) GB (11) 2 102 255 A

(54) Two-wire line for digital communication

(57) In duplex digital communication over a two-wire line 9, the signal components in the received signal due to crosstalk and echoes of the signal from ones own transmitter 1 are compensated by an adaptive digital filter (10) which includes the parallel arrangement of an adaptive digital transversal filter (11) and an adaptive recursive filter (12), the sum of their output signals (A, B) being the compensating signal. The setting of the recursive filter is decoupled from the setting of the transversal filter, and steps are taken to reduce the extent to which compensation is affected by a counter-signal. In one embodiment a TDM circuit enables the transversal filter to be operated in sections, the sections operating at a reduced rate.

Fig.1.
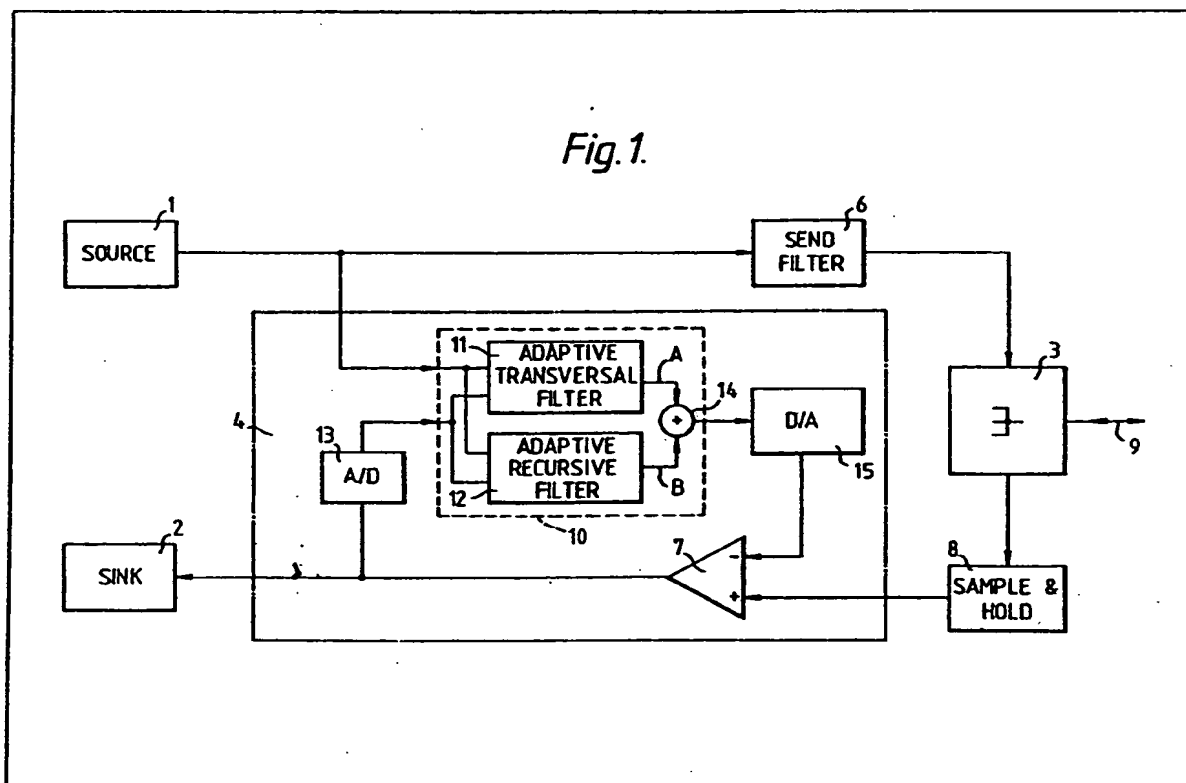
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Fig.1.
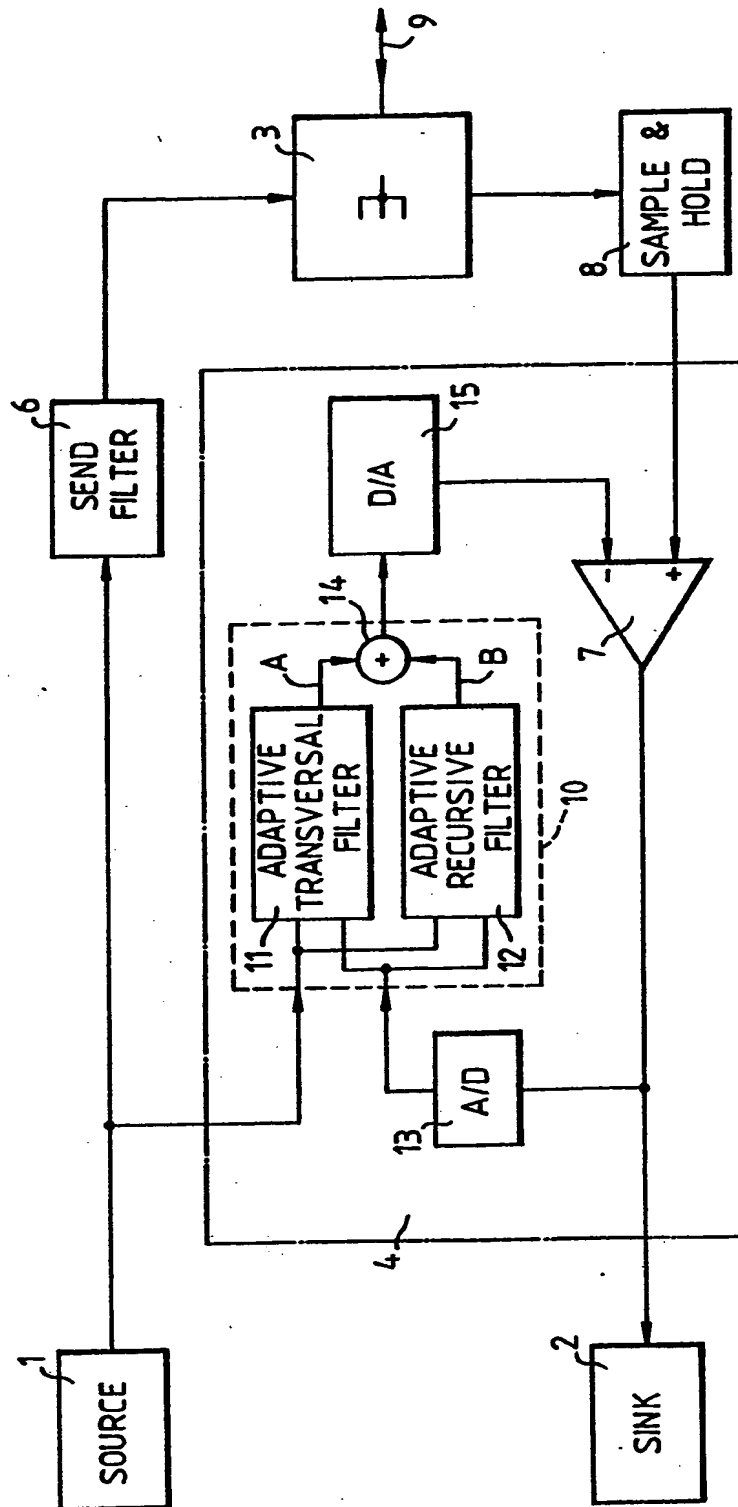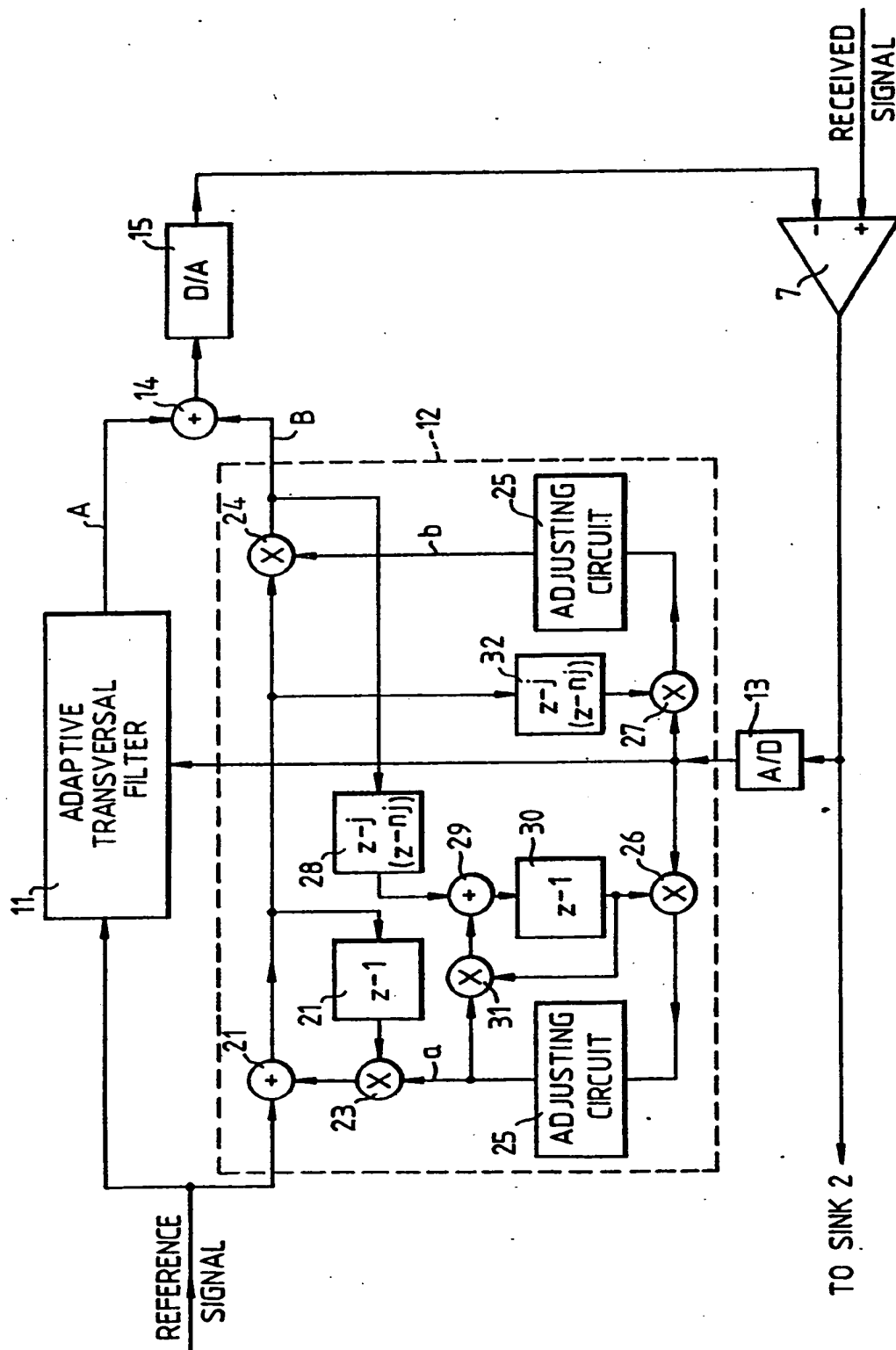
Fig.2.

to perform their computing operations, the individual filter sections can dispose of n-times the time, i.e., one clock period of the transversal filter is identical to one bit period and not to one

5 sampling cycle period. Accordingly, the time delay of the delay elements 50 is so chosen as to equal one bit period, and is indicated by Z^{-n}.

The clock frequency of the recursive filter is not affected by the reduction of the clock frequency in

10 the transversal filter. This frequency is in any case equal to the sampling cycle frequency.

Note that the TDM mode of operation of the transversal filter is independent of whether or not one uses the difference forming of the tapped

15 signals as described above. These TDM circuits 55 and 56, may therefore, also be used with prior art transversal filters where an operation-saving kind of working is desired.

We now explain, with reference to Fig. 6, an

20 example of the adjusting circuits 25 as shown in the drawings described above.

As mentioned, the adjusting circuits process the correlation products $X_{n-j} \cdot e_n$, wherein e_n indicates the value of the error signal function, and

25 X_{n-j} indicates the value of the signal to be multiplied thereby. These correlation products $X_{n-j} \cdot e_n$ are summated in an accumulator 60 · throughout G clock intervals, G being a suitable, preset number. After this number of clock

30 intervals, the accummulator 60 is reset to zero, and its previously calculated result, referred to as the correlation sum, is taken over by a multiplier 61. This multiplier multiplies the correlation sum by a factor $2^{-\beta}$, β being a natural number. The

35 multiplication which is actually a division, can be done by a simple shifting operation of the correlation sum by β positions, as that sum is in binary notation. Thus, we obtain the adjusting value Δq of the filter coefficient, which is added in

40 an accummulator 62, to the current value q_i of the coefficient, so that there is formed the successively following value q_{i+1} according to $q_{i+1} = q_i + \Delta q$. The accummulator 62 has a further input to which the initial value q_0 is applied. Thus, in the adjusting

45 circuits, the coefficients are iteratively adjusted in intervals of G clock periods.

CLAIMS

1. An arrangement for connecting a source and a sink to a two-wire line for digital communication

50 using duplex operation, with a hybrid circuit and an adaptive digital filter which, from the source signal, derives a compensating signal to suppress the interference signal which, due to the own source signal, is caused in the sync signal, with

55 the adaptive digital-filter coefficients being iteratively adjusted in dependence upon an error signal representing the non-suppressed interference-signal component, the adjusting values for adjusting the individual filter

60 coefficients equalling a function of a sum of correlation products formed over a defined number of clock intervals, in which the adjusting values are formed by the multiplication of signals derived from tapped signals of the digital filter, by

65 a function of the error signal, and in which the adaptive digital filter includes the parallel arrangement of an adaptive digital transversal filter and of an adaptive digital recursive filter, with the sum of the output signals thereof,

70 representing the compensating signal. .

2. An arrangement as claimed in claim 1, in which the recursive filter includes two filter sections, one of which contains recursive loop delaying its output signal by one clock period,

75 multiplies it by a first variable coefficient (a) and adds it to its input signal, in which the other filter section contains a multiplier multiplying its input signal by a second coefficient (b), in which the signal for forming the adjusting value of the first

80 coefficient (a) and to be multiplied by the function of the error signal, is derived from the output signal of the recursive filter, in which the signal for forming the adjusting value of the second filter coefficient (b), to be multiplied by the function of

85 the error signal, is derived from the output signal of the one filter section, and in which both the transversal filter and the recursive filter the function of the sum of correlation products $(X_{x-j} \cdot e_n)$ is this sum multiplied by $2^{-\beta}$, with β

90 being a natural number.

3. An arrangement as claimed in claim 2, in which in the recursive filter, the tapped signals used to form the coefficient adjusting values, are each delayed in delay circuits by j clock periods of

95 said transversal filter with j being the filter degree of the transversal filter.

4. An arrangement as claimed in claim 2 or 3, in which in the recursive filter, the filter section including the recursive loop precedes the filter

100 section containing the multiplier, and in which the function of the error signal is the error signal as digitized in an analog-to-digital converter.

5. An arrangement as claimed in claim 2 or 3, in which in the recursive filter, the tapped signals

105 used to form the coefficient adjusting values, pass through a difference-forming circuit which, from each of the successive digital values, subtracts the preceding digital value which has been delayed by one clock period.

110 6. An arrangement as claimed in claim 5 in which the function of the error signal is the sign of the time derivative of the error signal.

7. An arrangement as claimed in claim 5 or 6, in which in the recursive filter the filter section

115 including the recursive loop follow the filter section including the multiplier, in which the difference-forming circuit, as the tapped signal of the recursive filter, processes the output signal thereof, and in which the difference between two

120 successive digital values is the signal which, for forming the adjusting value of the second coefficient (b), is to be multiplied by the function of the error signal, and from which there is derived the signal which, to form the adjusting value of the

125 first coefficient, is to be multiplied by the function of the error signal.

8. An arrangement as claimed in claim 3 or 7, in which the signal as derived from the output of the recursive filter, passes through a recursive

filter loop whose output signal is the signal which, to form the adjusting value of the first coefficient (a), is to be multiplied by the function of the error signal, and in which as the filter coefficient of the
5   recursive filter loop there is used the value of the first filter coefficient (a).

9. An arrangement as claimed in claim 5, 6 or 7, in which the transversal filter the signals as derived from the tapped signals, each represent
10 the differences between two tapped signals appearing at neighbouring tapping points.

10. An arrangement as claimed in any one of the preceding claims, in which in said transversal filter there is used the same error-signal function
15 as in said recursive filter.

11. An arrangement as claimed in any one of the preceding claims, in which the transversal filter and the recursive filter are operated in the clock timing of a sample-and-hold device inserted
20 into said sink branch.

12. An arrangement as claimed in any one of claims 1 to 10, in which the transversal filter is

operated in the bit timing of the source and the sink, whereas the recursive filter is operated in the
25 clock timing of a sample-and-hold device inserted into said sink branch.

13. An arrangement as claimed in claim 12, in which in the transversal filter, the filter sections are divided into n different groups, n being
30 indicative of the number of samplings per bit, in which there is a first time-division multiplex circuit which, in the sampling cycle, connects the function of the error signal each time to another one of said n groups, in which there is a second
35 time-division multiplex circuit which, in the sampling cycle, connects each time another one of said n groups to the output of said transversal filter, and in which said two time-division multiplex circuits are operated in clock-controlled
40 synchronism.

14. An arrangement for connecting a source and a sink to a two-wire communication line, substantially as described with reference to the accompanying drawings.